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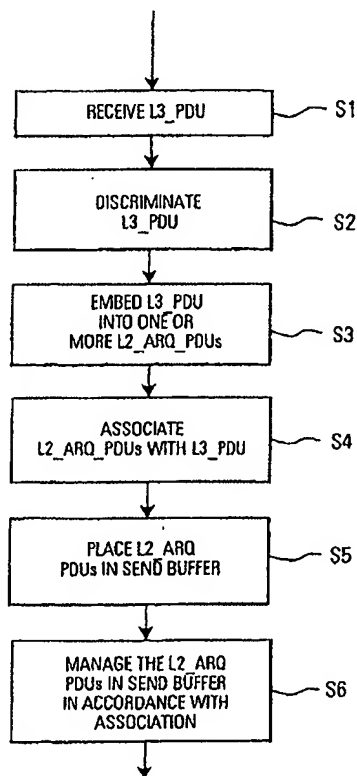
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(54) Title: **PROTOCOL DATA UNIT ENCAPSULATION METHOD**



(57) Abstract: The present invention relates to a data unit sending means and a method for controlling a data unit sending means, where data units of a first protocol (L2_ARQ) embed data units of a second protocol (L3) belonging to a higher layer, and said data units of said first protocol (L2_ARQ) are held in a send buffer means. According to the invention, the data units of the second protocol (L3) are discriminated, and the data units of the first protocol (L2_ARQ) that embed a particular data unit of the second protocol (L3) are associated with said particular data unit of the second protocol (L3), and the contents of the send buffer means is managed in accordance with said association.

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

[Background of the invention]

5

The present invention relates to a data unit sending means and a method for controlling a data unit sending means.

In the field of communications, the concept of packet
10 exchange is well known. A data packet is a given length of data whose structure is determined by a given protocol, i.e. a set of rules governing the exchange, manipulation and interpretation of such packets. Depending on the protocol, different names are used, such as frame, packet, etc. A more
15 generic term is protocol data unit (PDU), and the following description shall use the term data unit for simplicity.

The process of sending data via a packet exchange typically comprises a plurality of protocols, which are arranged in a
20 hierarchy. A schematic example of such a hierarchy is shown in Fig. 6. The example of Fig. 6 shows three layers, a higher layer referred to as L3, a layer below L3 referred to as L2_ARQ, and a lowest layer L1. In fact, the terms L3, L2_ARQ and L1 refer to protocols associated with these layers. As an
25 example, L3 can be the internet protocol IP, L2_ARQ may be the radio link protocol RLP known from GSM, and L1 can be any suitable physical layer protocol.

In accordance with the concept of layering, data units
30 associated with a higher layer are passed to a lower layer, e.g. from L3 to L2-ARQ in example of Fig. 6, where the lower layer protocol embeds the higher layer data units. The term "embedding" may refer to encapsulation or segmentation. In the case of encapsulation, a higher layer data unit is placed
35 into one lower layer data unit, whereas in the case of

segmentation, the higher layer data unit is segmented into smaller pieces of data, each piece being placed into a lower layer data unit.

5 One of the important aspects of protocol layering is that in a data communication, i.e. in a process where a given amount of data is being sent from a source to a destination, the overall path that is associated with a highest layer comprises sublinks associated with the lower layer protocols,
10 where the endpoints of a protocol of a given layer are called peers of said protocol. This concept is well known in the art and does not need to be described further here. Reference is made e.g. to the book "TCP/IP, The Protocols" by W.R. Stevens, Edison Wesley 1996.

15

[Problem underlying the Invention]

Specific problems in connection with the transmission of data occur in radio networks, due to the fact that radio links
20 typically have a poorer transmission quality than fixed lines. For the purpose of explanation, Fig. 3 shows the architecture for a generic cellular communication system. This system consists of a core network (CN) 100, and a part referred to as a radio access network (RAN) 110. The radio
25 access network is divided into controller nodes 101 and base transceiver stations (BTS) 102. The hierarchy of the network is such that the core network is connected to several controllers and the controllers are connected to several base stations. The base stations 102 communicate with mobile
30 stations (MS) 103.

A typical problem that will occur when sending data in the up-link direction (i.e. from a mobile station 103 to a base transceiver station 102) or in the down-link direction (from

the base transceiver station 102 to a mobile station 103) is that errors are introduced over the radio interface. Such errors are typically due to changes in the transmission quality, e.g. because the mobile station 103 moves around.

5 Another potential situation for data loss is a handover of a communication between a given mobile station 103 and a given base transceiver station 102 to another base transceiver station, when the mobile station moves into another cell. Both situations, namely a specific error condition or a
10 handover lead to the necessity of a link reset, in the course of which all data in the send buffer of the sending peer of the radio link is purged to thereby establish a "clean slate", such that communication may begin anew in a state unambiguously defined for both sender and receiver.

15

Due to the error characteristics of the radio interface, a so-called ARQ protocol (ARQ = Automatic Repeat reQuest) can optionally be executed between the mobile station and the radio access network to reduce the residual error rate. An
20 ARQ protocol comprises the function of acknowledging the correct receipt of data units by the receiving peer, where the sending peer implements mechanisms for retransmitting such data units that were not correctly received. In this way, the complete transmission of data is secured. It may be
25 noted that the use of an ARQ mechanism can be an option associated with a specific mode, i.e. that not every data unit needs to be sent with the ARQ mechanism activated. As an example, in connection with known protocols there are known a so-called numbered mode (or I-mode) in which ARQ is
30 activated, and a so-called unnumbered mode, in which no acknowledgment and consequently no retransmission occurs. The first mode is advantageous for data where secure transmission is a priority, the second mode is advantageous for data where

delay sensitivity is a priority and data loss is not so much of a problem, such as real-time voice-over-Internet data.

In the following, two known types of solutions for securing
5 user data from being lost in case of a handover of a ARQ
protocol communication between different network nodes will
be described.

According to a first solution, a protocol state transfer is
10 enacted, i.e. when a handover is performed, the whole state
including state variables and buffers is moved from the ARQ
entity in the RAN (i.e. the peer) to the new network node.
Using this mechanism, the ARQ entity in the mobile station
does not need to know when a handover occurs. Such a solution
15 is described e.g. in R. Cohen, B. Patel and A. Segall,
"Handover in a Micro-Cell Packet Switched Mobile Network",
ATM Journal of Wireless Networks, Volume 2, no. 1, 1996,
pages 13-25, or in S. Powel Ayanoglu, T.F. La Porta, K.K.
Sabdani, R.D. Gitlin, "AIRMAIL: A link layer protocol for
20 wireless networks", ATM/Baltzer Wireless Networks Journal,
Volume 1, 1995, pages 47-60.

The benefits of this solution are that no unnecessary re-
transmission of user data over the radio interface occurs,
25 and the ARQ protocol in the mobile station can be unaware of
the handover, which makes the implementation less expensive.

The disadvantage of this solution is, that it is limited to
handle intra-system handover. This means that both network
30 nodes between which the handover is executed must operate in
accordance with the same protocol. If a core network is
connected to multiple radio access networks of different
type, which do not use exactly the same ARQ protocol, this
solution cannot be used, because an inter-system handover is

necessary. Such situations will become more common in the future.

A different solution for securing user data is that of
5 providing an additional ARQ protocol. In this case, one ARQ
protocol is run between the mobile station and the radio
access network (the base station controller node) and takes
care of errors encountered of the radio interface. The second
ARQ protocol is run between the mobile station and the core
10 network. In case of data loss due to resetting the link
between the mobile station and the base station controller
(be it due to an error condition or a handover), this second
ARQ protocol will perform a re-transmission. As an example,
in GPRS (General Radio Packet Service) the first ARQ protocol
15 is called RLC (Radio Link Control Protocol) and the second
ARQ protocol is called LLC (Link Layer Control Protocol).

Although such an arrangement enables the handling of inter-
system handovers, it has disadvantages. First of all,
20 additional radio resources are consumed due to the overhead
introduced by the second ARQ protocol. As an example, in GPRS
the overhead per transmitted L3 data unit introduced by the
LLC protocol is in the order of 7 bytes. Compared to the size
of a Van Jacobson compressed TCP acknowledgment, which is
25 under 10 bytes, the size will almost be doubled when
transmitting TCP acknowledgments (in a L3 data unit). Also,
the implementation of two ARQ protocols in the mobile station
leads to higher costs in terms of memory and processing
power.

30

[Object of the Invention]

The object of the present invention is to provide a data
sending means and a corresponding control method that secure

data transmission, but which are applicable to intra-system handovers and inter-system handovers without adding unnecessary overhead. It may be noted that this object is not restricted to radio networks, because the avoidance of bandwidth waste is advantageous in any network. However, radio networks are a preferred application of the invention to be described in the following.

[Summary of invention]

10

This object is achieved by the subject matter described in the independent claims. Advantageous embodiments are described in the dependent claims.

15 In accordance with the present invention, a data unit sending means that operates in accordance with an ARQ protocol, referred to generically as L2_ARQ in the following, embeds higher layer data units of a protocol L3. L3 data units are discriminated, the L2_ARQ data units in which L3 data units
20 are embedded are associated with the L3 data units embedded therein, and the contents of the send buffer are managed in accordance with the association.

The process of handling the data units will be explained in a
25 general way in connection with Fig. 1. The L3 data units or PDUs are received (step S1) and then discriminated (step S2). Discrimination means that individual L3 data units are identified such that one may be discriminated from the other. It may be noted that this feature departs from the
30 conventional approach of making separate protocol layers completely transparent to one another, because in the present invention the L2_ARQ protocol is made "intelligent" in the sense that it may discriminate and differentiate individual L3 data units.

After the discrimination, the L3 data units are embedded
(i.e. encapsulated or segmented) into one or more L2_ARQ data
units (step S3). Then, the L2_ARQ data units are brought into
5 association with the higher layer L3 data units that they
form. In other words, a record is kept of which L2_ARQ data
units belong to which L3 data unit.

Then, the L2_ARQ data units are placed into a send buffer,
10 where the sending to the receiving L2_ARQ peer is performed
in accordance with any suitable or required flow control
method. For example, a widely used flow control method is
that of window-based flow control. The precise method and its
details will be determined by the specific L2_ARQ protocol,
15 such that this is of no importance to the present invention.

In accordance with the present invention, however, the
management of the send buffer is performed in accordance with
the association between the L2_ARQ data units and the higher
20 layer L3 data units that have been embedded in the L2_ARQ
data units. The term management refers to how the contents of
the buffer is controlled, i.e. under which conditions which
data units are deleted.

25 It may be noted that the order of steps indicated in Fig. 1
is only an example, and the basic principle of the invention
as specified by the claims may be implemented in any suitable
way.

30 By managing the contents of the send buffer, i.e. controlling
the deleting of data units therein in accordance with the
association between L2_ARQ data units and the higher layer L3
data units embedded therein, it is possible to achieve data
transmission security without two layers of ARQ protocols and

nonetheless enabling inter-system handover. This is due to the fact that by managing the buffer in accordance with the association of L3 data units and L2_ARQ data units, any loss of L3 data units can be avoided at the L2_ARQ level. As a
5 consequence, an ARQ mode above the L2_ARQ level is superfluous. At the same time, as the loss of data is avoided by a mechanism implemented around the send buffer, an inter-system handover poses no problem.

10 It should be noted that the L2_ARQ protocol does not necessarily send all data units in an ARQ mode. Much rather, the invention is applicable to any protocol, i.e. also such protocols that provide transmission modes in which no re-transmission occurs. However, according to a preferred
15 embodiment, the buffer management for such L2_ARQ data units that are sent in an ARQ mode is performed in such a way that a given L2_ARQ data unit is only deleted from the send buffer means if acknowledgments for all L2_ARQ data units associated with the same L3 unit as said given L2_ARQ data unit have
20 been received. In this way, all L2_ARQ data units belonging to one L3 data unit are held in the send buffer until the last L2_ARQ data unit associated with that L3 data unit has been acknowledged, i.e. until all L2_ARQ data units associated with a particular L3 data unit have been
25 acknowledged.

Then, in the event of a reset, i.e. a resetting of the numbering of L2_ARQ data units, or a handover, the L2_ARQ data units belonging to the last L3 data unit for which not
30 all L2_ARQ data units have been acknowledged will simply be sent again. In this way, a part of said L3 data unit may be sent twice, but in any case the L3 data unit is sent completely, such that no retransmission on the L3 level or higher (e.g. TCP) is necessary. In the event of a handover,

the L3 data units in the send buffer may simply be transferred to the new node, regardless of said new node operating according to the same L2_ARQ protocol or a different one. In other words, an inter-system handover is no
5 problem, because no other information besides the buffer contents (in terms of L3 data units), such as state variables, etc., must be handed over.

The present invention will now be described on the basis of
10 preferred and detailed embodiments that serve the purpose of explaining the invention and are not to be seen as restrictive. Reference will be made to the accompanying figures, in which

15 Fig. 1 describes the control of a data unit sending means according to a basic example;

Fig. 2 is a schematic representation of a data unit sending means according to the invention;

20

Fig. 3 shows the architecture of a generic cellular communication system;

Fig. 4 is an explanatory diagram for describing a detailed
25 example of the invention;

Fig. 5 is an explanatory diagram for explaining the association between L3 data units and L2 data units; and

30

Fig. 6 is a representation of a generic protocol stack.

[Detailed Disclosure of the Invention]

Fig. 2 schematically shows the arrangement of elements for embodying a data unit sending means of the present invention. 1 refers to a discriminator, 2 to an embedder, 3 to a buffer and 4 to a control means. As can be seen, data units from the L3 layer arrive and are discriminated by discriminator 1 at the L2_ARQ layer. The discrimination result is passed to the control means 4, that then performs the association of L2_ARQ data units generated in the embedder 2 with the L3 data units. Then the L2_ARQ data units are passed to the buffer 3, where the management of the buffer contents is performed in accordance with the association between the L2_ARQ data units and the higher layer L3 data units that they embed. As already mentioned previously, the specific flow control performed by the control means 4 will depend on the specific L2_ARQ protocol.

As already mentioned in connection with Fig. 1, the structure shown in Fig. 2 is only a schematic example for the purpose of explanation, and other arrangements are possible, which the skilled person will choose as is suitable or desired.

For the purpose of the following description of detailed embodiments, it will be assumed that the L2_ARQ protocol provides two reliability modes for the transmission of data units, namely one with acknowledgment and re-transmission, and another without re-transmission. The first mode, which is an ARQ mode, will be referred to as the numbered mode or I-mode, whereas the second will be referred to as the unnumbered mode or UI-mode. It will also be assumed that the buffer will contain respective queues associated with the modes. In other words, there will be an I-queue and an UI-queue. Naturally, the present invention is by no means restricted to such an arrangement, as there may be a larger

number of reliability modes, such as unreliable, semi-reliable and fully reliable, and there can be a corresponding number of queues in the buffer. The semi-reliable or fully reliable transmission modes can either be combined with in-
5 sequence or out-of-sequence delivery, as will be explained in more detail further on.

The following embodiments will be described on the basis of the protocol arrangement shown in Fig. 6, where L3 is used to
10 refer to any network protocol, e.g. the internet protocol IP. It may be that the L3 data units are embedded in a specific framing scheme, as e.g. provided by the point-to-point protocol PPP. Thus, L3 refers to any protocol that produces a corresponding data unit that is transferred to the layer
15 below, i.e. the L2_ARQ layer.

As already discussed above, the L2_ARQ layer refers to a link layer protocol that embeds L3 data units into L2_ARQ data units, where the embedding preferably is a potential
20 segmentation of larger L3 data units into smaller L2_ARQ data units and/or concatenation of several L3 data units into L2_ARQ data units. As mentioned above, the L2_ARQ protocol implements at least two modes, namely an ARQ mode (I-mode), and a non-acknowledged mode (UI-mode). The basic concept of
25 an ARQ mode such as the I-mode is well known in the art, such that a further description of details is not necessary. It is sufficient to say that the L2_ARQ protocol contains rules for how the re-transmission of L2_ARQ data units is done, on the basis of the presence or absence of acknowledgment messages
30 and retransmission requests for specific data units. As is necessary for any ARQ mechanism, the L2_ARQ data units sent in accordance with the acknowledgment mode are buffered in the send buffer, where they must at least be held until their correct receipt has been acknowledged. The preferred buffer

management mechanism of the present invention shall be described further on.

For better explaining the invention, reference will be made
5 to the architecture of a generic communication system as shown in Fig. 4. As can be seen, a mobile station (MS) 500 has an L3 peer that communicates with a corresponding counterpart in the core network (CN) 400. The core network 400 is connected to two different radio access networks 401
10 and 402. Each radio access network comprises a plurality of radio access network nodes, such as e.g. base station controllers (BSC) and base transceiver stations (BTS), where the schematic representation of Fig. 4 only shows one base transceiver station 403, 404 for each of the radio access
15 networks 401 and 402, for the purpose of simplicity. Also, it may be noted that the core network can be connected to more than two radio access networks.

There exist two peer entities of the L2_ARQ protocol, one
20 running in the mobile station 500 and one in the respective radio access network 401 or 402. In the example of Fig. 4, each radio access network has its own L2_ARQ protocol, referred to as L2_ARQ(RAN1) for radio access network 401 and as L2_ARQ(RAN2) for radio access network 402.

25

Fig. 4 also shows a physical layer protocol L1 provided below the L2_ARQ protocol. The L1 peers are directly associated with the physical connection, i.e. the transceiver in the mobile station 500 and the transceiver in the base
30 transceiver station 403 or 404, whereas the L2_ARQ protocol entity on the network side resides in a network node of the respective radio access network.

It will be assumed that a reset of the link between two L2_ARQ peers can occur, e.g. due to a predetermined error condition. More specifically, a link reset will lead to the data unit numbering being reset, to thereby be able to start communication anew. There are different error conditions that may lead to such a resetting of the data unit numbering, for example if a given data unit has been re-transmitted a predetermined number of times, without an acknowledgment having been received. Another error condition can be that an acknowledgment is received for a data unit that was never sent. Both cases indicate that the link is strongly disturbed, such that a reset is necessary. In conventional systems, the data contained in the send buffer is simply purged in the course of a reset, to thereby give the sending peer and receiving peer an unambiguously defined starting situation.

Another potential data loss situation is that of a handover, where a communication is handed from one network node of a radio access network to another. Such a handover may be either inside of a given radio access network (intra-system) or may be between two different types of radio-access networks (inter-system). When a handover occurs, this may result in moving the execution point for the L2_ARQ protocol entity to a new physical node where a L2_ARQ entity will be started and continue the communication with a new L2_ARQ peer. As can be seen in Fig. 4, this means that in an inter-system handover, the communication not only needs to be handed over from e.g. base station 403 to base station 404, but a handover will also occur inside of the mobile station 500, as the transmission must be handed from L2_ARQ (RAN1) to L2_ARQ (RAN2). In any case, a handover will include a link reset, as the two peers of the communication require a defined starting point.

Now the preferred buffer management of the send buffer for a sending peer (be it in the mobile station, or be it in a network node) will be described. The sender of both L2_ARQ
5 entities in a system is only allowed to delete L2_ARQ data units from its send buffer when all L2_ARQ data units associated with a whole L3 data unit have been acknowledged by the peer entity. If concatenation of L3 data units is used, a L2_ARQ data unit may not be deleted if it includes a
10 segmented L3 data unit that was not fully received. Further, if the peer L2_ARQ receiver uses in-sequence delivery, the L2-ARQ sender is only allowed to remove the L2_ARQ data units using in-sequence removal.

15 This basic principle will be explained in more detail in connection with Fig. 5. Fig. 5 shows a simple example for the segmentation/concatenation of L3 data units into L2_ARQ data units. An L2_ARQ protocol entity has segmented three L3 data units, denoted L1#-L3# into five L2_ARQ data units, denoted
20 L2#1-L2#5. As may be seen, L3#1 is segmented into L2#1-L2#3, L3#2 is segmented into L2#3-L2#4, and finally L3#3 is completely enclosed in L2#5.

The following table 1 shows examples of the contents of the
25 L2_ARQ send buffer when different data units have been acknowledged by the peer entity. The sender works according to the above-described mechanism, i.e. L2_ARQ data units are only deleted if complete L3 data units have been acknowledged. Table 1 indicates the differences for in-
30 sequence and out-of-sequence delivery.

Acknowledged PDUs by peer (L2#x)

Send buffer
contents (L2#x)

1	2	3	4	5	In- sequence delivery	Out-of- sequence delivery
x	x		x	x	1-5	1-4
x	x	x		x	3-5	3-4
x	x	x	x		5	5
		x	x	x	1-5	1-3
		x	x		1-5	1-3, 5
				x	1-5	1-4
x	x	x	x		5	5
	x	x	x	x	1-5	1-3

5

As can be seen in the first line, in the case of in-sequence delivery all L2_ARQ data units remain in the send buffer, because the first L3 data unit L3#1 has not been completely acknowledged because L2#3 was not acknowledged. In the case of out-of-sequence delivery, the data unit L2#5 has been deleted, as the acknowledgment of L2#5 means that L3#3 has been completely acknowledged. In the second line, it can be seen that the acknowledgment of L2#1 to L2#3 means that L3#1 has been completely acknowledged, such that L2#1 and L2#2 may be deleted, but due to the fact that L2#4 has not been acknowledged, L2#3 may not be deleted as L2#3 also is associated with L3#2.

In the third line, L2#1 to L2#4 were acknowledged, i.e. L3#1 and L3#2. Consequently, only L2#5 remains in the send buffer. In the case of line 4, L2#3 to L2#5 have been acknowledged, such that L3#2 and L3#3 have been acknowledged, so that for out-of-sequence delivery only L2#1 to L2#3 remain in the

20

buffer, whereas for in-sequence delivery all L2_ARQ data units remain, because the first unit was not acknowledged. The remaining examples are self-explanatory.

- 5 In a general sense, any time during the protocol operation, the L2_ARQ entity must be able to provide information about the contents of its send buffer in terms of the L3 data units. This information can be the identities of the L3 data units in accordance with any suitable addressing scheme, or
10 the L3 data units themselves, where these L3 data units are those for which the associated L2_ARQ data units have not been fully acknowledged by the peer entity.

Now an example will be described, in which a link reset
15 occurs, i.e. the resetting of the data unit numbering, without a handover. In other words, the sending and receiving peers remain the same, but the numbering of the I-mode data units is reset, e.g. due to a given error condition. In this case, the sending peer will simply renumber the L2_ARQ data
20 units in its send buffer in such a way that the first L2_ARQ data unit of the new sequence is the first L2_ARQ data unit associated with the last L3 data unit that was not completely acknowledged. In other words, when considering the example shown in Fig. 5, if one assumes that L2#1 to L2#3 have been
25 acknowledged, which means that L3#1 has been acknowledged, the new sequence will begin with L2#3 as its first data unit, because L3#2 was not fully acknowledged prior to the reset. In this way there is no possibility of data loss in the course of the reset.

30

In the example just described, the segmentation performed prior to the link reset was retained. Preferably, the link reset will be performed by additionally resegmenting the L3 data units for which not all L2_ARQ data units were

acknowledged. In other words, when taking the above assumption that L2#1 to L2#3 were acknowledged, L3#2 and L3#3 would be resegmented such that the first L2_ARQ data unit of the reset sequence would only be associated with L3#2. As can
5 be seen, this has the advantage that the end part of L3#1 is not unnecessarily retransmitted, i.e. in a general sense that there is no unnecessary retransmission of data.

It may be noted that for the above examples, it makes no
10 difference if the sending peer is in the mobile station or the network node.

Now the situation of a handover will be described.

15 According to one embodiment, when a handover occurs, which results in moving the L2_ARQ protocol execution to a new physical node, the old L2_ARQ entity will be terminated and a new L2_ARQ entity will be started. Before the old entity is terminated, the contents of the send buffer, i.e. the
20 unacknowledged L3 data units, will be transferred to the newly established L2_ARQ entity. The new entity will then resume the transmission starting with the unacknowledged L3 data units received from the terminated L2_ARQ entity.

25 In other words, in accordance with the present invention, the new L2_ARQ entity will start sending the first L2_ARQ data unit associated with the last L3 data unit that was not completely acknowledged prior to termination of the old L2_ARQ entity. In this way, similar to the above example of a
30 reset without a handover, the complete transmission of all L3 data units is secured, without the necessity of running an ARQ mode on any higher level to protect against such losses. Also, due to the fact that L3 data units are passed on, an inter-system handover is no problem. In other words, no state

variables need to be passed on, and the new node can handle the L3 data units in its own particular way, i.e. according to its particular L2_ARQ protocol. This especially means that the L3 data units may for example be resegmented differently
5 in the new node.

The mechanisms with which unacknowledged L3 data units are transferred between the old and the new L2_ARQ entity may be selected in any suitable or desirable way in accordance with
10 the specific hardware and protocols involved. In the network, the transfer of unacknowledged L3 data units can be done e.g. by "pushing back" the data units to the core network, which then takes care of the data unit delivery/transfer to the new L2_ARQ entity. This can be very useful in case of an inter-
15 system handover, where the different radio access networks are not connected to each other. An alternative is that the old network node will directly transfer the L3 data units to the new network node, if this new node is known. This alternative is advantageous in an intra-system handover.

20 When the data unit sender is in the mobile station, two different handover procedures can be distinguished for the L2_ARQ entity. In case of an intra-system handover, the L2_ARQ entity will only have to perform a reset. This may
25 involve the renumbering of already segmented L2_ARQ data units, or the resegmentation and/or reconcatanation of the send buffer contents, after which the protocol is restarted. When an inter-system handover is performed, the unacknowledged L3 data units may have to be transferred to a
30 new L2_ARQ entity. This entity may be executed in the same physical device (mechanical/electronic piece, chip, CPU, etc.) or in a different physical device located in the same mobile station. The precise details of such a transfer from e.g. L2_ARQ (RAN1) to L2_ARQ (RAN2) of mobile station 500 in

Fig. 4 will depend on the precise nature of the radio access networks, the employed protocols, the hardware of the radio network and mobile station, etc. It is clear that this can be done in any suitable or desirable way under the specific
5 conditions of the situation.

According to another embodiment, the handover is not performed by a direct transfer of the L3 data units left in the send buffer, much rather a multicast group is formed.
10 More specifically, a set of at least two L2_ARQ entities in the network is created, that forms a multicast group, e.g. an IP multicast group. Only one of the L2_ARQ entities from the group at a time communicates with the peer entity in the mobile station, and this L2_ARQ entity will be referred to as
15 the "serving" L2_ARQ entity. The rest of the L2_ARQ entities in the multicast group do not have a peer-to-peer communication with the mobile station, and will be denoted as the "passive" L2_ARQ entities.

20 The members of the multicast group can be chosen in any suitable or desirable way. Preferably, in a cellular mobile communication system, the group includes all nodes that are potential handover candidates, i.e. those nodes associated with the cells adjacent to the cell in which the mobile
25 station is presently located. Naturally, this is only an example, and other criteria are possible for determining the members of the group.

It may be noted that the multicast group consisting of L2_ARQ
30 entities is not a fixed group, but may be adapted in accordance with how the mobile station moves about. For example, when the mobile station moves from one cell to another, the passive members of the multicast group are changed to those cells lying around the new cell. In other

words, when the mobile station moves around in the network, a passive member of the group can be deleted and new ones may be added to the group.

- 5 There are different possibilities of using the multicast group to perform a handover. According to one alternative, the L2_ARQ peers work in the same way as previously described, i.e. those L3 data units are retained for which not all associated L2_ARQ data units have been acknowledged.
- 10 Then, when the handover is performed, the unacknowledged L3 data units will be multicast to the whole group and the new serving L2_ARQ entity will resume the transmission starting with the multicast data units, i.e. the first data unit will be associated with the last L3 data unit for which not all
- 15 associated L2_ARQ data units were acknowledged prior to the handover. Although this solution entails the transmitting of a larger amount of data than in the previous embodiment, it has the advantage that the serving node does not have to know to which node the L2_ARQ communication is handed over.

20

- According to another alternative, the L2_ARQ peers again perform the buffer management as described above, until a condition occurs that indicates that a handover might have to be performed. Then, a corresponding control process
- 25 predicting the handover can trigger the start of a multicast session. When the start is triggered, the L2_ARQ begins by multicasting the unacknowledged L3 data units currently residing in its send buffer. The whole multicast group will then receive the new L3 data units. Either the core network
- 30 or the serving L2_ARQ entity will be responsible for this transmission. The serving L2_ARQ entity will then in addition continue to regularly send multicast messages to inform the passive L2_ARQ entities which L3 data units can be discarded from the send buffers. That is, information about the L3 data

units that have been acknowledged by the peer L2_ARQ entity is multicasted. When a handover occurs, the serving L2_ARQ entity will multicast a data unit discard message if new L3 data units have been acknowledged since the last discard message was sent. Alternatively, the serving L2_ARQ that is handing over the communication can transmit a multicast message that indicates with which L3 data unit to continue sending after handover.

10 In order to accomplish the above system, some kind of addressing scheme must be employed for the L3 data units. Any suitable or desirable scheme that uniquely identifies the L3 data units, and in the case of in-sequence delivery of L3 data units identifies the internal order, may be used.

15

One example for an addressing scheme is the use of sequence numbering for each L3 data unit. The precise implementation of such a scheme, e.g. the nature of a common protocol between the members of the multicast group, is of no relevance for the present invention, as long as the above described function is given.

Up to now, the buffer management and handling of L2_ARQ data units in an acknowledgment mode (the I-mode) were discussed.

25 The management of the L2_ARQ data units of the non-acknowledgment mode (UI-mode) in the send buffer is somewhat different, but the handling after reset or after handover is basically the same. More specifically, the L2_ARQ data units that are in the UI-queue are simply deleted or discarded after having been sent. In this sense, the contents of the UI-queue in the send buffer always reflects those data units that have not yet been sent. When a reset or a handover occurs, the new L2_ARQ entity will simply continue the procedure by sending those L2_ARQ data units of the UI-mode

that have not yet been sent. The process of bringing the L3 data units that have not yet been sent from the old L2_ARQ entity to the new L2_ARQ entity during a handover is exactly as described for the I-mode L2_ARQ data units. In other
5 words, this can be done by direct transfer, by pushing back through the core network, or in the way of the above-described multicast group.

According to a preferred embodiment, the UI-mode data units
10 are however treated somewhat differently, namely in the event of a reset or a handover, all those L2_ARQ data units that are associated with a L3 data unit for which only a part of the L2_ARQ data units was sent, are deleted prior to recommencing sending after the reset or the handover. This
15 has the advantage that an unnecessary transmission of L2_ARQ data units can be avoided. More specifically, one functionality of the L2_ARQ protocol will be that of error detection, which means performing an error check and discarding L3 data units that have incurred transmission
20 errors. Typically, in the course of a reset or a handover, where parts of a given L3 data unit have been sent, said given L3 data unit will be incomplete and therefore discarded. As a consequence, the sending of the remaining L2_ARQ data units associated with said given L3 data unit is
25 superfluous.

As already mentioned above, one of the advantages of the present invention is that no ARQ mode needs to be run above the L2_ARQ level. However, it is preferred that the L2_ARQ
30 protocol implements some sort of error check and error control. For example, the receipt of faulty L3 data units should be recognized, and these faulty data units should be discarded. In this way, the system of the present invention becomes particularly effective, because then those I-mode

L2_ARQ data units that only form part of an L3 data unit are discarded, and due to the buffer management of the present invention, the complete L3 data unit is sent thereafter (see above description of reset and handover with respect to I-mode L2_ARQ data units), such that the complete transmission of L3 data units is secured.

Consequently, the L2_ARQ implementation will not only be able to perform error detection on the L2_ARQ level (e.g. as will typically be associated with the acknowledgment mode for L2_ARQ data units), but will also be able to perform error detection on the L3 level.

One of the important advantages of the present invention is that it only requires the modification of a data unit sending means. This greatly simplifies the implementation of the present invention into existing systems.

Reference signs in the claims are intended for a better understanding and do not restrict the scope.

[Claims]

1. Method for controlling a data unit sending means, said data unit sending means having a send buffer means (3) for holding data units to be sent and said data unit sending means being arranged to
- send data units of a first protocol (L2_ARQ) to another peer of said first protocol (L2_ARQ), and
 - embed data units of a second protocol (L3) belonging to a higher layer than said first protocol (L2_ARQ) into data units of said first protocol (L2_ARQ),
- said method comprising the steps:
- discriminating said data units of said second protocol (L3),
- associating data units of said first protocol (L2_ARQ) with data units of said second protocol (L3),
- managing the contents of said send buffer means in accordance with the association between the data units of said first protocol (L2_ARQ) and said second protocol (L3).
2. Method according to claim 1, wherein said first protocol provides at least one acknowledgment mode (I) in which the acknowledgment of the correct receipt of data units sent to said other peer is provided, and said managing comprises deleting a given data unit of said first protocol (L2_ARQ) that belongs to said acknowledgment mode from said send buffer means only if acknowledgments for all data units of said first protocol (L2_ARQ) associated with the same data unit of said second

protocol (L3) as said given data unit of said first protocol (L2_ARQ), have been received.

3. Method according to claim 2, wherein said acknowledgment mode of said first protocol (L2_ARQ) comprises arranging said data units of said first protocol (L2_ARQ) stored in said send buffer means in a sequence, each data unit being associated with a sequence number that identifies the place of said each data unit in said sequence, said method further comprising:

if a condition occurs that leads to the sequence numbering having to be reset, retaining the sequence of data units of said first protocol (L2_ARQ) remaining in said send buffer means and renumbering said sequence such that the first data unit of said first protocol (L2_ARQ) associated with the last data unit of said second protocol (L3) for which no acknowledgment for all associated data units of said first protocol (L2_ARQ) was received, becomes the first data unit of said first protocol (L2_ARQ) of the reset sequence.

4. Method according to claim 3, wherein said condition leading to a resetting of the sequence numbering is a link reset due to an error condition or the start of a handover.
5. Method according to one of claims 1 to 4, wherein said data unit sending means is a mobile station or a radio network node in a mobile communication network, and said first protocol (L2_ARQ) controls a radio link.
6. Method according to claim 2, wherein said data unit sending means is arranged to also be able to embed said

data units of said second protocol (L3) in data units of a third protocol (L2_ARQ') different from said first protocol (L2_ARQ), and said data unit sending means is also arranged to be able to perform a transition of a communication from said first protocol (L2_ARQ) to said third protocol (L2_ARQ'), where for performing such a transition said method further comprises:

- terminating the sending of data units of said first protocol (L2_ARQ),
- generating data units of said third protocol (L2_ARQ') on the basis of data units of said second protocol (L3), where the data units of said third protocol (L2_ARQ') are associated with those remaining data units of said second protocol (L3) for which the associated data units of said first protocol (L2_ARQ) were not all acknowledged prior to the termination of the sending of data units of said first protocol (L2_ARQ).

20

7. Method according to claim 6, wherein said third protocol (L2_ARQ') also provides at least one acknowledgment mode in which the acknowledgment of the correct receipt of data units is provided, said acknowledgment mode of said third protocol (L2_ARQ') comprises arranging said data units of said third protocol (L2_ARQ') in a sequence, each data unit being associated with a number that identifies the place of said each data unit in said sequence, said method further comprising:

30

numbering the data units of said third protocol (L2_ARQ') such that the first data unit of said third protocol (L2_ARQ') associated with the last data unit of said second protocol (L3) for which no acknowledgment

for all associated data units of said first protocol (L2_ARQ) was received before terminating the sending of data units of said first protocol (L2_ARQ), becomes the first data unit of said third protocol (L2_ARQ') in the new sequence of the third protocol (L2_ARQ').

8. Method according to claim 6 or 7, wherein said data unit sending means is a mobile station in a radio communication system, and said first and third protocols control a radio link.

9. Method for performing a handover of a communication between a first data unit sending means and a destination receiver means to a second data unit sending means and said destination receiver means, said first data unit sending means being controlled in accordance with claim 2, comprising

terminating the sending of data units from said first data unit sending means,

controlling the second data unit sending means to send to said destination receiver means all those data units of said second protocol (L3) remaining in said send buffer of said first data unit sending means at the time of termination, for which the associated data units of said first protocol (L2_ARQ) were not all acknowledged prior to the termination of the sending of data units from said first data unit sending means.

10. Method according to claim 9, further comprising transmitting said data units of said second protocol (L3) that remain in said send buffer of said first data unit sending means at the time of terminating, to said

second data unit sending means upon terminating the sending of data units from said first data unit sending means.

- 5 11. Method according to claim 9, further comprising storing in said second data unit sending means data units of said third protocol (L3) being sent by said first data sending means, said storing being done prior to terminating the sending of data units from said first data unit sending means, and transmitting information relating to the management of data units of said second protocol (L3) in said send buffer of said first data unit sending means to said second data unit sending means.
- 10
- 15 12. Method according to claim 11, wherein said second data unit sending means is one of a plurality of data unit sending means, and data units of said third protocol (L3) being sent by said first data sending means and being stored in said second data unit sending means prior to terminating the sending of data units from said first data unit sending means, are stored in all of data unit sending means of said plurality.
- 20
- 25 13. Method according to claim 12, wherein said first and second data unit sending means, said plurality of data unit sending means and said destination are part of a cellular mobile communication system, said first and second data unit sending means and said plurality being radio network nodes, and said destination receiver means being a mobile station, and said plurality being defined as the group of radio network nodes belonging to cells that lie adjacent to the cell to which the first data unit sending means belongs.
- 30

14. Method according to one of claims 11 to 13, wherein said transmitting of information comprises regularly sending discard messages indicating which data units of said second protocol (L3) have been deleted from said send buffer of said first data unit sending means prior to termination of sending data units from said first data unit sending means and/or sending a start message upon termination of sending of data units from said first data unit sending means, where said start message informs said second data unit sending means with which data unit of said second protocol (L3) to start sending after handover.
15. Method according to one of claims 11 to 14, wherein said data units of said second protocol (L3) are ordered into a sequence, each data unit in said sequence being associated with a sequence number representing the position of said each data unit in said sequence, where said transmitting of information to said second data unit sending means comprises transmitting one or more of said sequence numbers.
16. Method according to one of claims 9 to 15, wherein said first and second data unit sending means and said destination receiver means are part of a mobile communication system, said first and second data unit sending means being radio network nodes and said destination receiver means being a mobile station.
17. Method according to one of claims 1 to 16, wherein said first protocol provides at least one non-acknowledgment mode (UI) in which no acknowledgment of the correct receipt of data units sent to said other peer is

provided, and said managing comprises deleting a given data unit of said first protocol (L2_ARQ) that belongs to said non-acknowledgment mode from said send buffer means after said given data unit was sent, and if a link
5 reset or handover occurs, all remaining data units of said first protocol (L2_ARQ) that are associated with a data unit of said third protocol (L3) for which only a part of the associated data units of said first protocol (L2_ARQ) was sent, are deleted prior to recommencing
10 sending after reset or prior to handing over the send buffer contents.

18. Data unit sending means having a send buffer means (3) for holding data units to be sent and said data unit
15 sending means being arranged to send data units of a first protocol (L2_ARQ) to another peer of said first protocol (L2_ARQ), and having

an embedding means (2) for embedding data units of a
20 second protocol (L3) belonging to a higher layer than said first protocol (L2_ARQ) into data units of said first protocol (L2_ARQ),

a discriminating means (1) for discriminating said data
25 units of said second protocol (L3),

an associating means (4) for associating data units of
said first protocol (L2_ARQ) with data units of said
second protocol (L3),

30

a control means (4) for managing the contents of said send buffer means in accordance with the association between the data units of said first protocol (L2_ARQ) and said second protocol (L3).

19. Data unit sending means according to claim 18, wherein
said first protocol provides at least one acknowledgment
mode (I) in which the acknowledgment of the correct
5 receipt of data units sent to said other peer is
provided, and said control means (4) for managing the
buffer means (3) is arranged to delete a given data unit
of said first protocol (L2_ARQ) that belongs to said
acknowledgment mode from said send buffer means only if
10 acknowledgments for all data units of said first
protocol (L2_ARQ) associated with the same data unit of
said second protocol (L3) as said given data unit of
said first protocol (L2_ARQ), have been received.
- 15 20. Data unit sending means according to claim 19, wherein
said acknowledgment mode of said first protocol (L2_ARQ)
comprises arranging said data units of said first
protocol (L2_ARQ) stored in said send buffer means in a
sequence, each data unit being associated with a
20 sequence number that identifies the place of said each
data unit in said sequence, said data unit sending means
further being arranged to:
- 25 if a condition occurs that leads to the sequence
numbering having to be reset, retain the sequence of
data units of said first protocol (L2_ARQ) remaining in
said send buffer means and renumber said sequence such
that the first data unit of said first protocol (L2_ARQ)
associated with the last data unit of said second
30 protocol (L3) for which no acknowledgment for all
associated data units of said first protocol (L2_ARQ)
was received, becomes the first data unit of said first
protocol (L2_ARQ) of the reset sequence.

21. Data unit sending means according to claim 20, wherein said condition leading to a resetting of the sequence numbering is a link reset due to an error condition or the start of a handover.
- 5
22. Data unit sending means according to one of claims 18 to 21, wherein said data unit sending means is a mobile station or a radio network node in a mobile communication network, and said first protocol (L2_ARQ) controls a radio link.
- 10
23. Data unit sending means according to claim 19, wherein said data unit sending means is arranged to also be able to embed said data units of said second protocol (L3) in data units of a third protocol (L2_ARQ') different from said first protocol (L2_ARQ), and said data unit sending means is also arranged to be able to perform a transition of a communication from said first protocol (L2_ARQ) to said third protocol (L2_ARQ'), where for performing such a transition said data unit sending means is further arranged to:
- 15
- 20
- terminate the sending of data units of said first protocol (L2_ARQ),
- 25
- generate data units of said third protocol (L2_ARQ') on the basis of data units of said second protocol (L3), where the data units of said third protocol (L2_ARQ') are associated with those remaining data units of said second protocol (L3) for which the associated data units of said first protocol (L2_ARQ) were not all
- 30
- acknowledged prior to the termination of the sending of data units of said first protocol (L2_ARQ).

24. Data unit sending means according to claim 23, wherein
said third protocol (L2_ARQ') also provides at least one
acknowledgment mode in which the acknowledgment of the
correct receipt of data units is provided, said
5 acknowledgment mode of said third protocol (L2_ARQ')
comprises arranging said data units of said third
protocol (L2_ARQ') in a sequence, each data unit being
associated with a number that identifies the place of
said each data unit in said sequence, said data unit
10 sending means further being arranged to:

number the data units of said third protocol (L2_ARQ')
such that the first data unit of said third protocol
(L2_ARQ') associated with the last data unit of said
15 second protocol (L3) for which no acknowledgment for all
associated data units of said first protocol (L2_ARQ)
was received before terminating the sending of data
units of said first protocol (L2_ARQ), becomes the first
data unit of said third protocol (L2_ARQ') in the new
20 sequence of the third protocol (L2_ARQ').

25. Data unit sending means according to claim 23 or 24,
wherein said data unit sending means is a mobile station
in a radio communication system, and said first and
25 third protocols control a radio link.

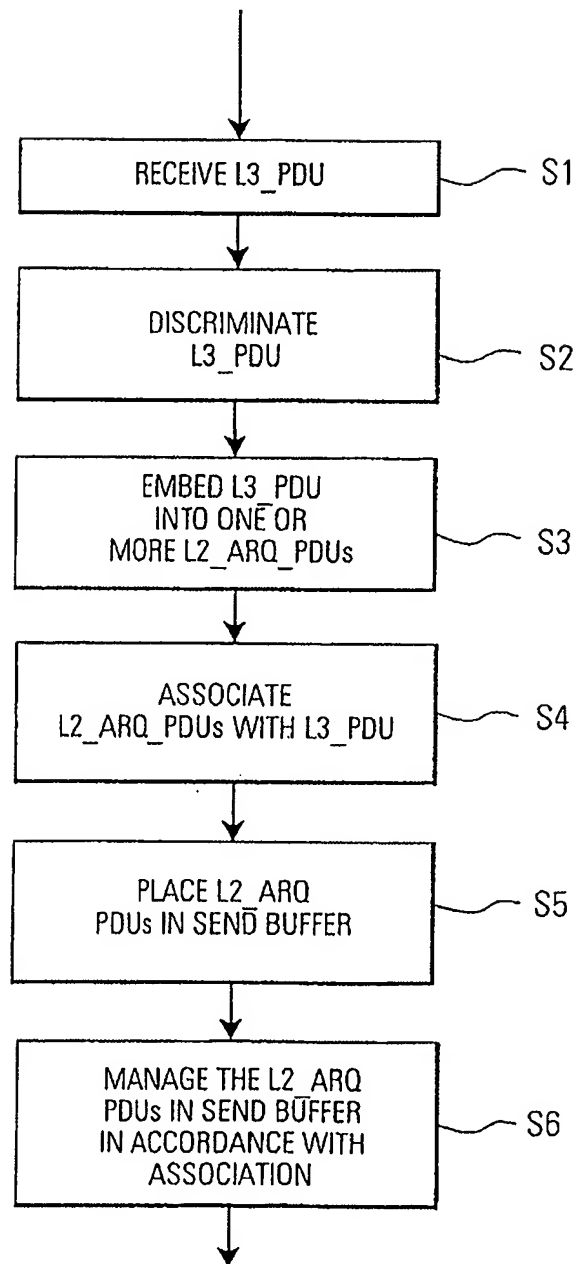
FIG.1

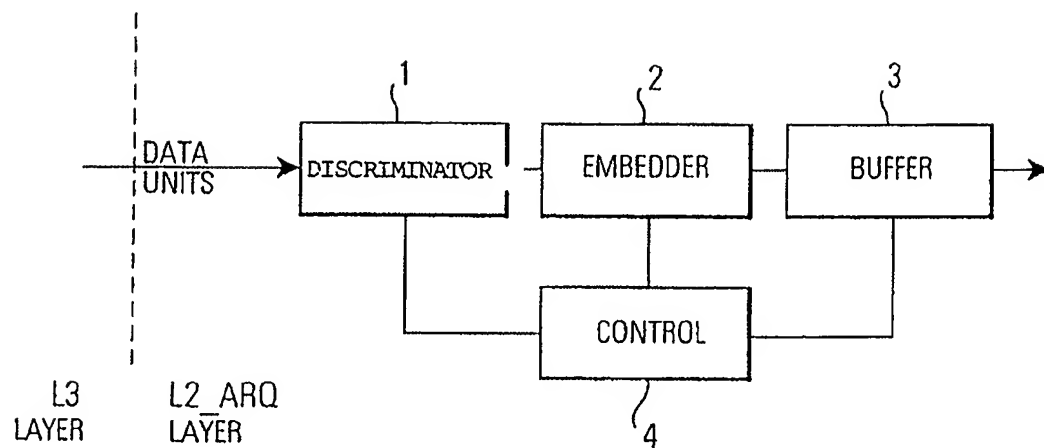
FIG.2

FIG.3

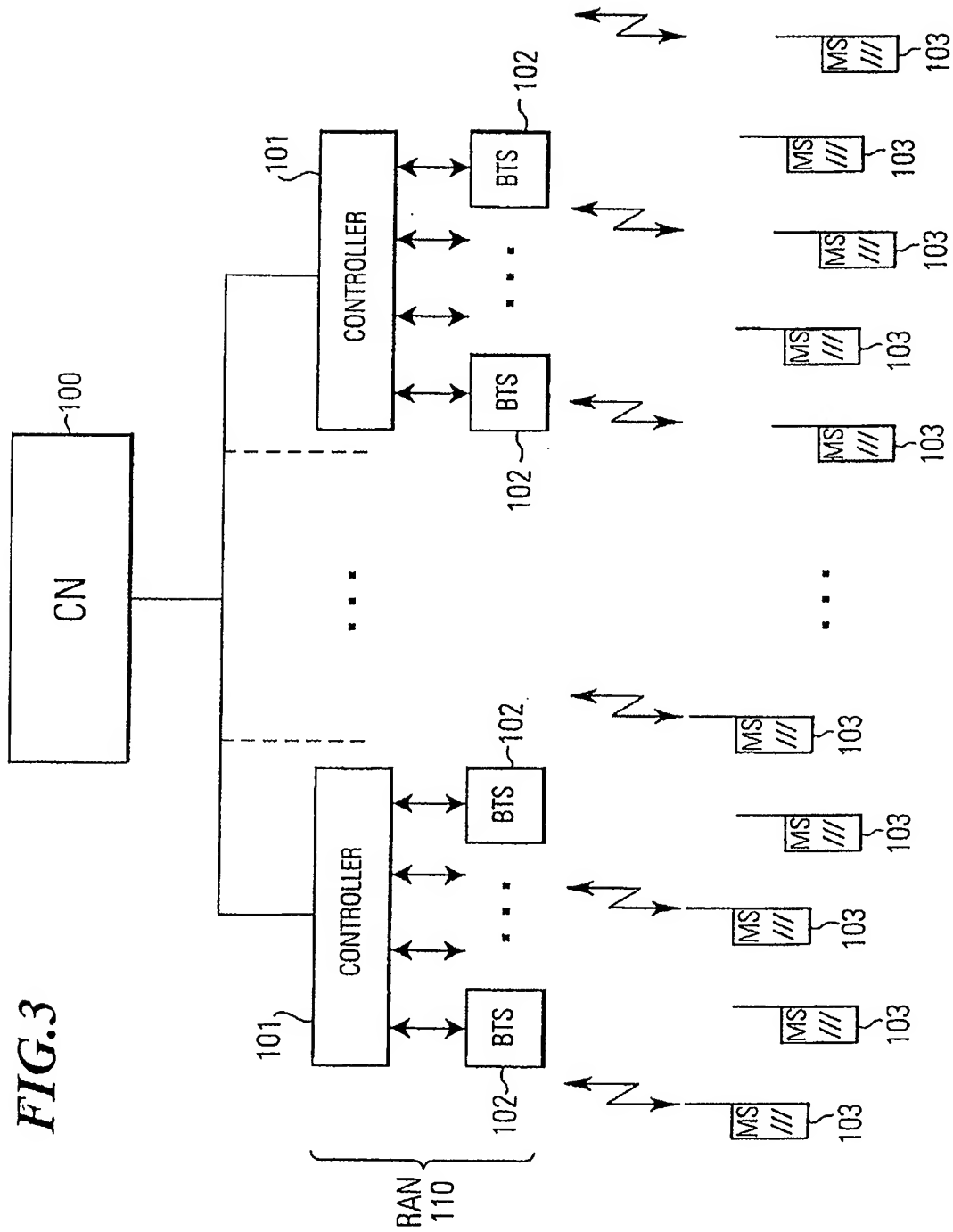


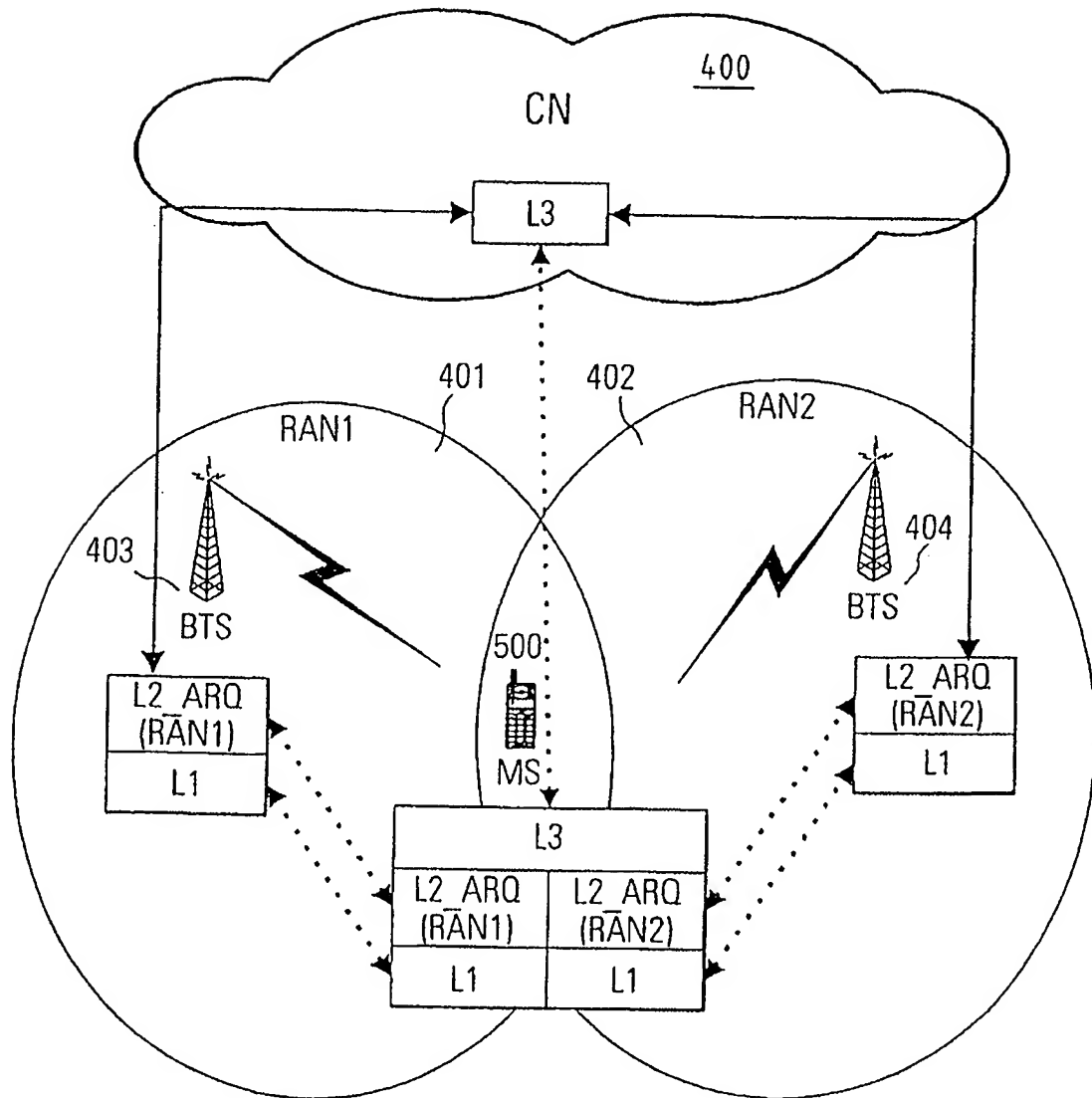
FIG. 4

FIG.5

L 3 # 1		L 3 # 2		L 3 # 3
L 2 # 1	L 2 # 2	L 2 # 3	L 2 # 4	L 2 # 5

FIG.6

L 3
L 2 _ ARQ
L 1

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/EP 00/04558

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L29/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC, COMPENDEX, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 572 865 A (ALCATEL NV) 8 December 1993 (1993-12-08) abstract column 4, line 2 -column 5, line 41 ---	1, 18
A	WO 96 21984 A (NOKIA TELECOMMUNICATIONS OY ;KARI HANNU H (FI); KARPPANEN ARTTO (FI) 18 July 1996 (1996-07-18) abstract claim 1 figures 4A-4G --- -/--	1-25

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

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18 August 2000

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 00/04558

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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